NRC Program Review
1.1 Title and Investigators

Human-Centered Earth Science Information Processing

Timothy S. Shaw, Eileen S. Rotthoff, Amulya K. Garga
Penn State Applied Research Laboratory (ARL)

David L. Hall
Penn State School of Information Sciences and Technology (IST)

Applied Research Laboratory
The Pennsylvania State University
P.O. Box 30
State College, PA 16804-0030

1.2 Goal and Technical Objectives

<u>Goal</u>

Demonstrate the human-centered fusion and presentation of complex, multi-dimensional terrestrial and atmospheric data and processes

1.2 Goal and Technical Objectives

<u>Technical Objectives</u>

- **Fuse non-commensurate multi-source earth science data**
  - Images
  - Signals
  - Textual reports

- **Perform automated reasoning to assist human analysis**
  - Model explicit multi-expert knowledge via fuzzy-logic rules
  - Incorporate implicit sensor data via neural networks
  - Combine explicit and implicit information via hybrid reasoning approach

- **Explicitly design for human-in-the-loop data interpretation**
  - Immersive multi-sensory visualization environments
  - User tailored interfaces, multi-discipline collaboration

- **Provide decision-quality information with measures of performance**
  - Utilize predictive analysis and alternative hypotheses evaluation
  - Focus research via problem-centered analysis and metrics

1.3 Technical Problem Statement

- **NASA is collecting increasing volumes of earth science data**
  - Additional sensors and increasing sensor/processing capabilities
  - Earth science community needs to increase predictability horizons

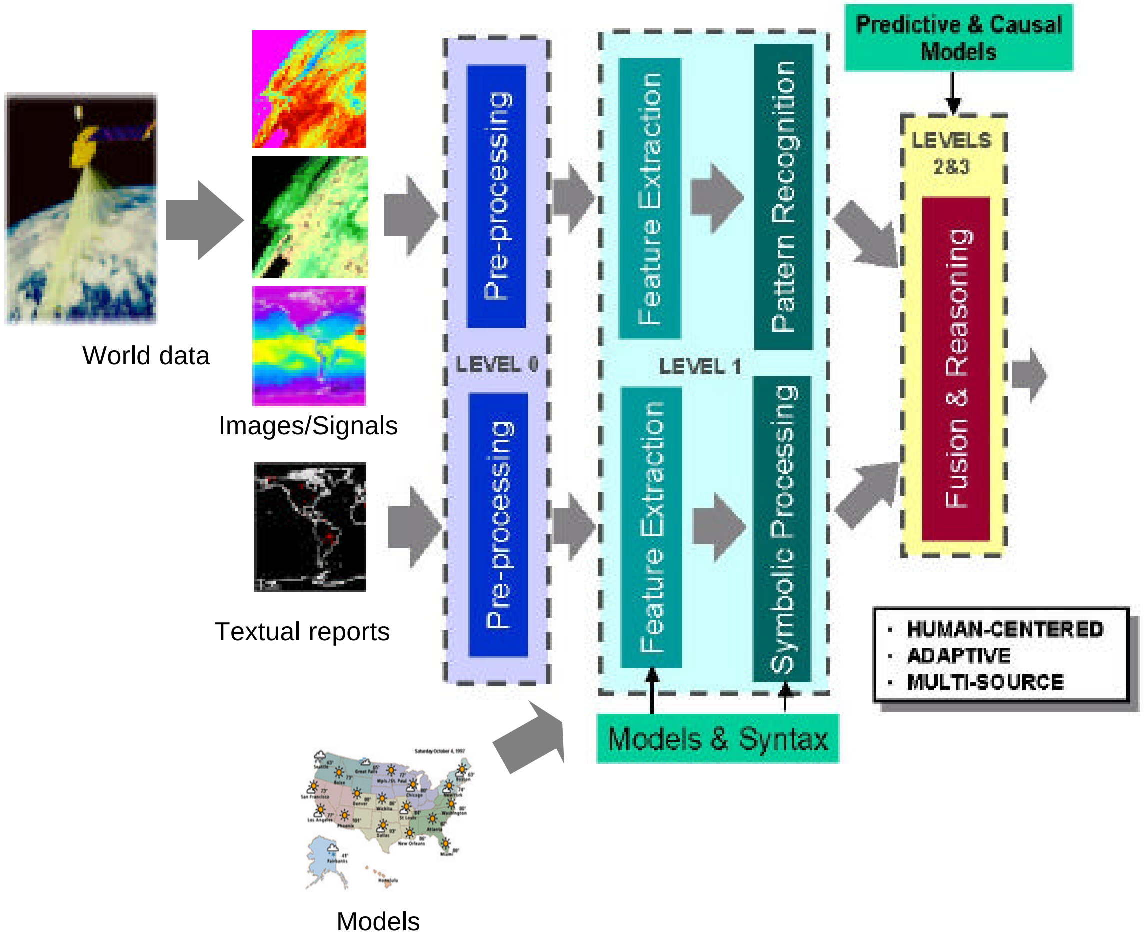
- **Heterogeneous earth science data fusion challenging**
  - Multiple geo-spatial and temporal resolutions, times scales
  - Availability of training data for automated reasoning techniques

- **Human analysis of large data sets from remote sensors difficult**
  - Difficult to represent parametric uncertainty
  - Cognitive biases in presentations
  - Traditional human computer user interfaces can make decision-making difficult

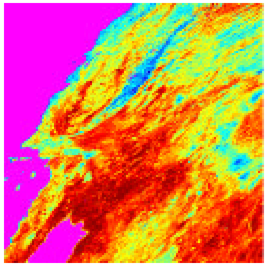
Innovative strategies and techniques are required to provide increased opportunities for data discovery from data provided by the NASA EOS.

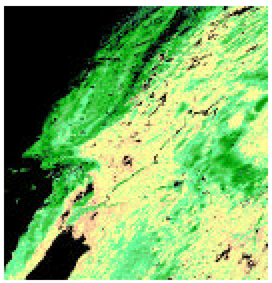
1.4 Technical Approach

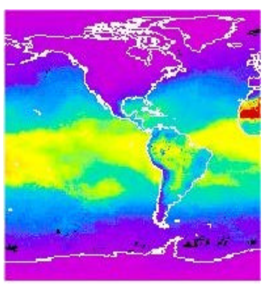
Automated contextual interpretation and human-centered interaction with multi-source earth science data

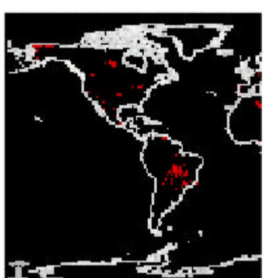


1.5 Data and NASA Relevance









Earth science data examples

Data Product	Source	Data Format
Land Surface Temperature Day/night land temperature per grid	Terra satellite, MODIS sensor Bands 20, 22, 23, 29, 31, 32, 33	HDF-EOS, Integerized sinusoidal projection
Leaf Area Index One-sided leaf area per unit ground area	Terra satellite, MODIS sensor Bands 1 - 7	HDF-EOS, Integerized sinusoidal projection
Precipitable Water Column water vapor amounts	Terra satellite, MODIS sensor Bands 1, 2, 17, 18, 19	HDF-EOS, Equal angle grid
Fire Event Detected fire indication with time and location	ERS-1&2, ATSR sensor Bands of 1.6, 3.7, 11.0, 12.0 micrometers	Text report, Point location

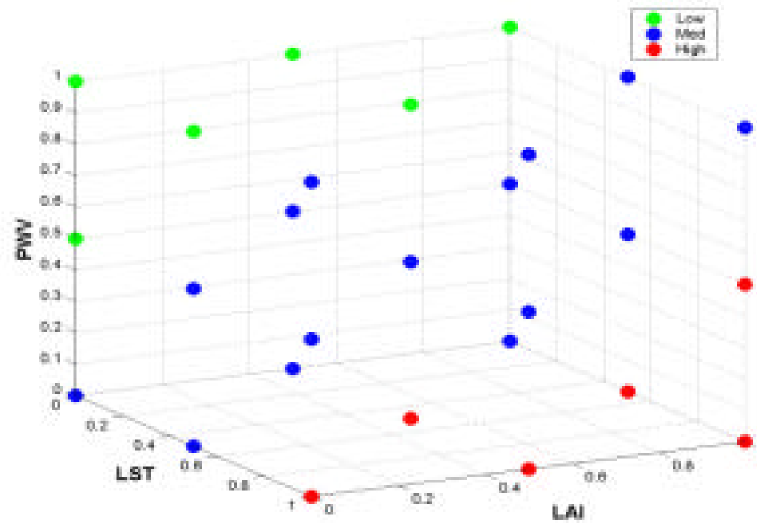
Widely-available multi-source remote-sensed data and textual information can be fused to make interpretations and inferences using hybrid reasoning techniques.

1.6 Accomplishments and Preliminary Findings

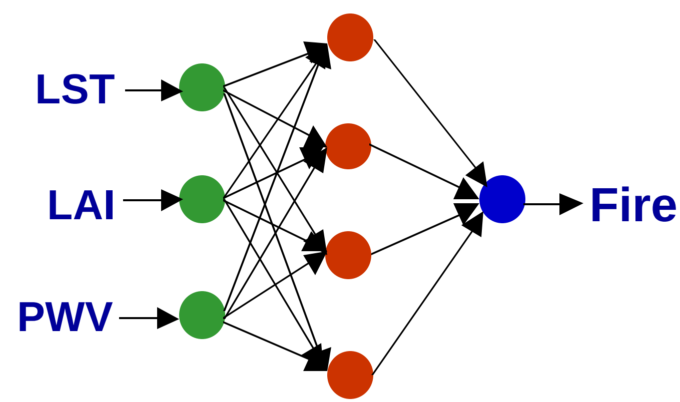
- **Initial hybrid reasoning approach for**
- **prediction of forest fires**
- Rules represent domain knowledge linking observables and probability of fire
    - Land Surface Temperature (LST)
    - Leaf Area Index (LAI)
    - Precipitable Water Vapor (PWV)

- Neural network trained on rules learns the domain knowledge
    - Trained on 70% of the rules

Visualization of the Rule Base



Fire Prediction Neural Network



1.6 Accomplishments and Preliminary Findings

Established an effective human-centered immersive environment testbed for earth science data analysis

- Immersive presentation of multiple types of data
- Developed geo-temporal visual paradigm to coherently represent remote sensor and textual data

1.7 Technical Significance of Progress and Expected Impact on NASA

Initial progress toward end-to-end system approach to demonstrate causal links from heterogeneous data

<u>Expected Impact</u>

- **Exploration of large heterogeneous data sets**
    - Correlate data with variety of spectral, spatial, temporal characteristics
    - Facilitate discovery of unexpected spatial/temporal patterns, features

- **Complex process characterizations**
    - Fuse multiple time sets from multiple sensors
    - Discover leading indicators to extend prediction horizons

- **Integration of advanced visualization and analysis tools**
    - Multi-sensory representation of earth science data
    - Comprehensive spatial and temporal presentation
    - Human-in-the-loop data analysis consistent with cognitive processing

URL, Facilities, Personnel Assigned to Project

1.8 URL

Human-centered Earth Science Information Processing
(http://www.arl.psu.edu/facilities/facilities/sea_lab/nasa_ames.html)

1.9 Facilities

Penn State ARL Synthetic Environment Applications Laboratory (SEA Lab)

- Access to advanced visualization, simulation, and collaboration technologies

1.9 Personnel

Penn State Applied Research Laboratory

- Amulya K. Garga
- Eileen S. Rotthoff
- Timothy S. Shaw

Penn State School of Information Sciences and Technology

- David L. Hall

Students:

- Rashaad E. Jones (Morgan State University)
- Kurt A. Campbell (Penn State)
- Christopher J. Oster (Penn State)

1.10 References

T. Shaw, E. Rotthoff, A. Garga, D. Hall, "Human-centered Remote Sensor Information Fusion“ (abstract accepted), National Symposium on Sensor and Data Fusion, August 2002, San Diego, CA.

T. Shaw, “Remote Sensor Information Visualization”, U.S. Navy Journal of Underwater Acoustics (abstract accepted), August 2002.

T. Shaw, D. Hall, A. Garga, and E. Rotthoff, “Human-Centered Remote Sensor Data Fusion”, *Combating Uncertainty with Fusion Workshop*, Center for Advanced Studies in the Space Life Sciences, Woods Hole, MA, April 2002.

T. Shaw, D. Hall, A. Garga, and E. Rotthoff, “Human-Centered Earth Science Information Processing”, *Intelligent Systems Program/Intelligent Data Understanding (IDU) Project Workshop*, University of Montana, June 2001.